Dynamic simulation of in vitro micro-tissue formation using a particle-based deformable cell model

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ABSTRACT

The three dimensional nature of our bodily tissues regulate auto- and paracrine signalling and establish natural biophysical conditions affecting both cell function and fate. Micro-tissues are excellently suited to study these important biological behaviours. By seeding cells on micro-wells of a non-adhesive substrate such as agarose, the cells effectively de-wet from the surface and become spherical three-dimensional micro-tissues. First, the cells actively migrate towards each other to form a loose cluster of cells. Next, the clusters condensate into smooth, spherical micro-aggregates.

In this study, we use particle-based models to simulate the dynamics of aggregate formation and to investigate the most important parameters affecting the final aggregate shape, cell morphology, mechanical stress, and the dynamics of its formation (see Figure 1). We construct a phase-diagram of this system, which predicts de-wetting as a function of cell contractility, cell-substrate adhesion and cell motility.

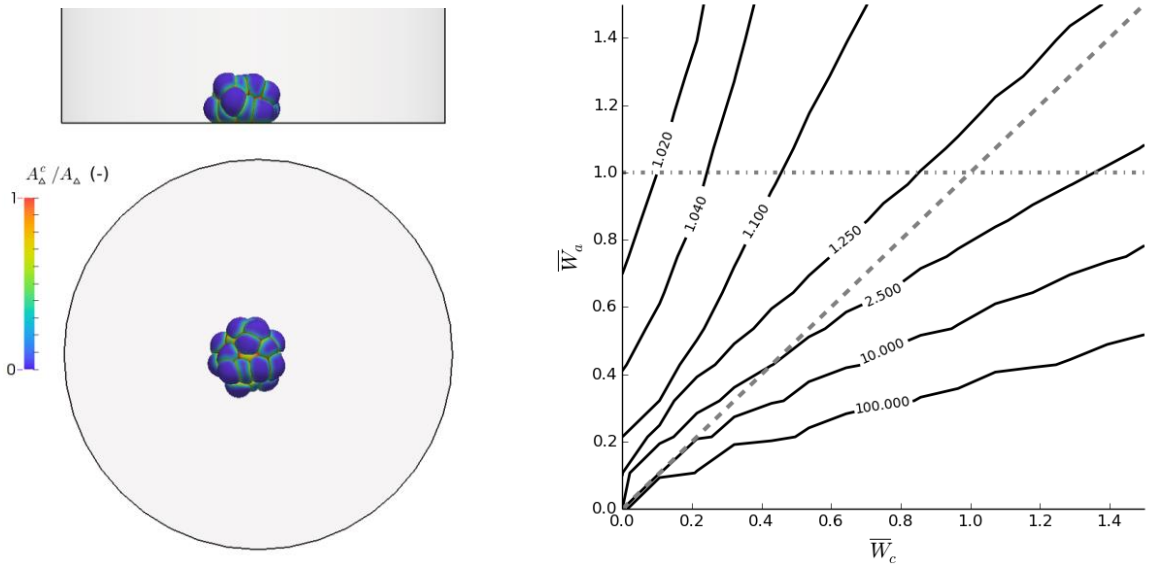

Figure 1: Left: Simulated cell aggregates with deformable cells. Color code: contact area. Right: "de-wetting" map with iso-lines of 2D relative density for cell-substrate and cell-cell adhesion (W_a and W_c). High densities indicate de-wetting.

[1] Moreira Teixeira, L. S., et al. "High throughput generated micro-aggregates of chondrocytes stimulate cartilage formation in vitro and in vivo." European cells & materials 23 (2012): 387-399.

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